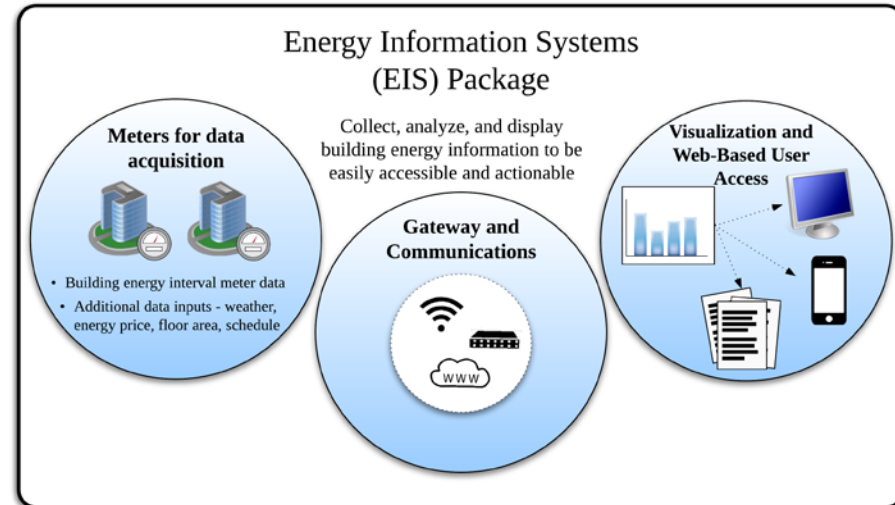
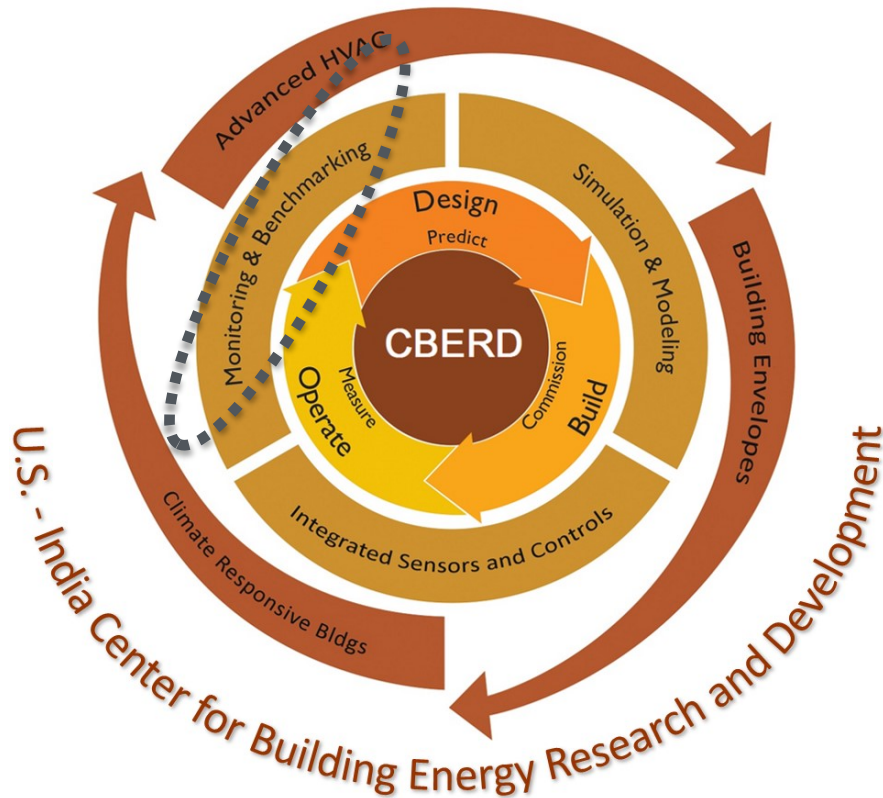


CBERD Monitoring and Benchmarking

2017 Building Technologies Office Peer Review



Project Summary

Timeline:

Start date: Oct 2012; Planned end date: Sep 2017

Key Milestones:

1. Technical requirements for packaged EIS for three target segments
2. Packaged EIS Demonstrations for three target segments
3. New benchmarking methods to address unique Indian benchmarking needs.

Budget:

Total DOE \$ to date: \$600 K (FY'13- 16)

Total future DOE \$: \$150 K (FY'17)

Target Market/Audience: Commercial Buildings

- EIS vendors
- Building owners and operators
- Benchmarking programs

Institutional partners

Center for Environmental Planning and Technology (CEPT), India

Industry partners

1. Mazzetti
2. Synapsense
3. Schneider Electric
4. Wipro Eco-energy (Now UTC)



Project Goals:

- Develop cost effective, scalable systems to monitor real time performance in commercial buildings which can be integrated into EIS and metering products with broad applicability in the U.S. and Indian markets
- Enhance and expand whole-building and system level benchmarking methods adapted for India and applicable to US benchmarking

Project start
Oct 2012

Oct 2012

Oct 2013

Oct 2014

Oct 2015

Oct 2016

NOW

Project end
Sep 2017

Oct 2017

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

Purpose and Objectives: Problem Statement, Target and Impact

Problem Statement:

Benchmarking and Energy Information Systems (EIS) can enable significant energy savings. However, technical challenges exist to their wider application:

1. Energy Information Systems are commercially available and growing in technical capability

But high transaction costs – skill and time required to configure, install and use EIS – limit market reach.

2. Energy Benchmarking tools are well established

But lack flexibility in required data inputs vs. desired accuracy.

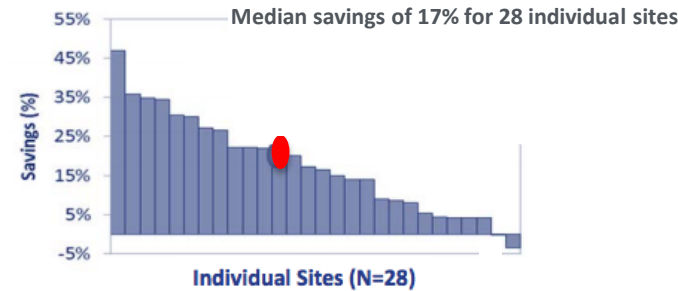
Target Market:

Broad applicability to commercial buildings sector, primarily retrofit in the US and new construction India.

- In the US, potential savings ~2 Quads primary energy (~10% savings x ~20Q commercial sector energy use)

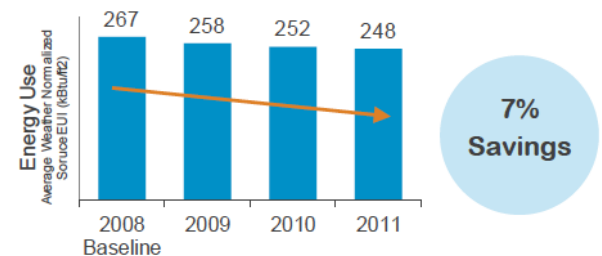
Target Audience:

- EIS vendors
- Owners, operators of commercial buildings
- Benchmarking programs



Energy savings reported by EIS users in Better Buildings Alliance Study

Energy Savings in Portfolio Manager

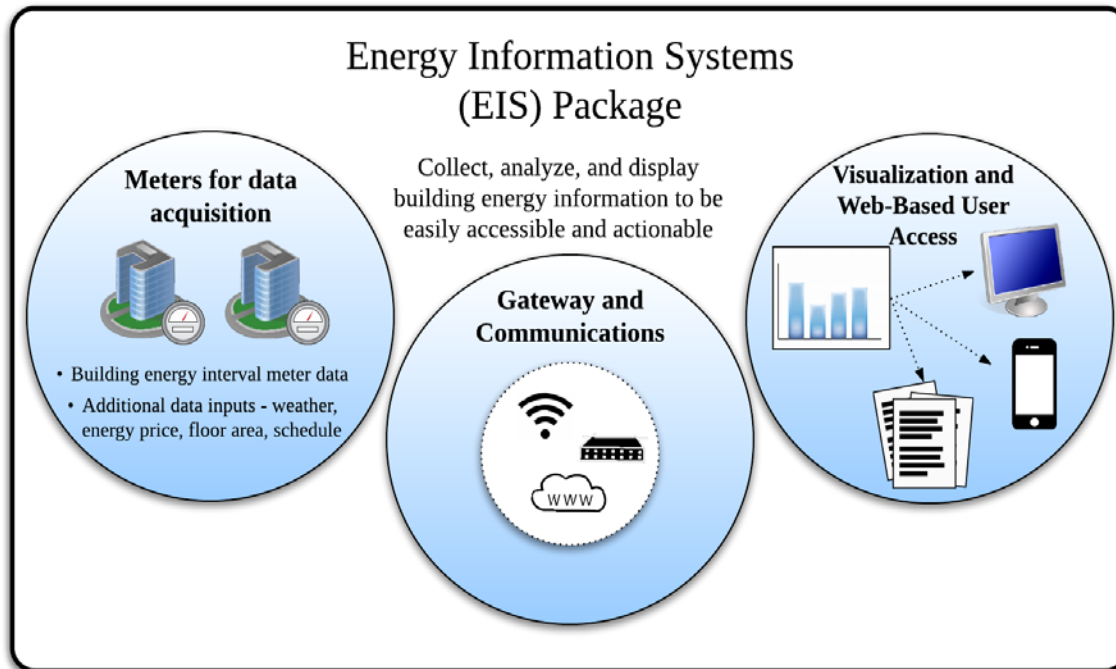


Source: ENERGY STAR Data Trends factsheet

Purpose and Objectives: Outputs and Impact

Energy Information Systems (EIS)

Technical requirements for packaged, scalable, cost effective “EIS in a box” for the US (underserved building sectors) and India (emerging market)



Outputs

Near Term (during project duration):

- EIS guides for specific building types
- Technical requirements for EIS packages for specific market segments
- EIS package demonstrations in real buildings

Intermediate-to-long term (after project):

- EIS packages offered by vendors
- Scaling up of EIS installations in commercial buildings.

3 components

- (1) Meters
- (2) Gateway
- (3) Software & UI

2-tiers

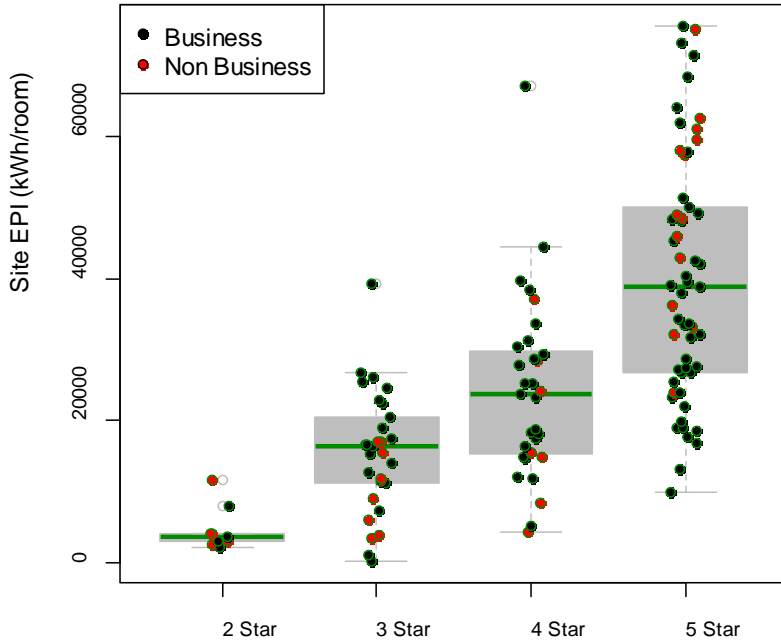
- (1) Entry
- (2) Advanced

3 target sectors

- (1) Healthcare
- (2) Hotels
- (3) Offices

Purpose and Objectives: Impact and Outputs

Benchmarking (Bx)



Example - Analysis of Eco-III hotels dataset used to identify variables for graduated benchmarking

Benchmarking methods that enable broader use of benchmarking tools within market-facing deployment programs and policies.

- “Graduated” benchmarking model that allows tradeoff between data inputs and accuracy.
- Benchmark scores with error bars allow users to apply them appropriately.

Outputs

Near Term (during project duration):

- Benchmarking analysis of hotel and hospital datasets using univariate, bivariate and regression analysis
- Graduated Benchmarking models and methods for hotels and hospitals

Intermediate-to-long term (after project duration):

- Uptake of Graduated Benchmarking by programs in India and the US.

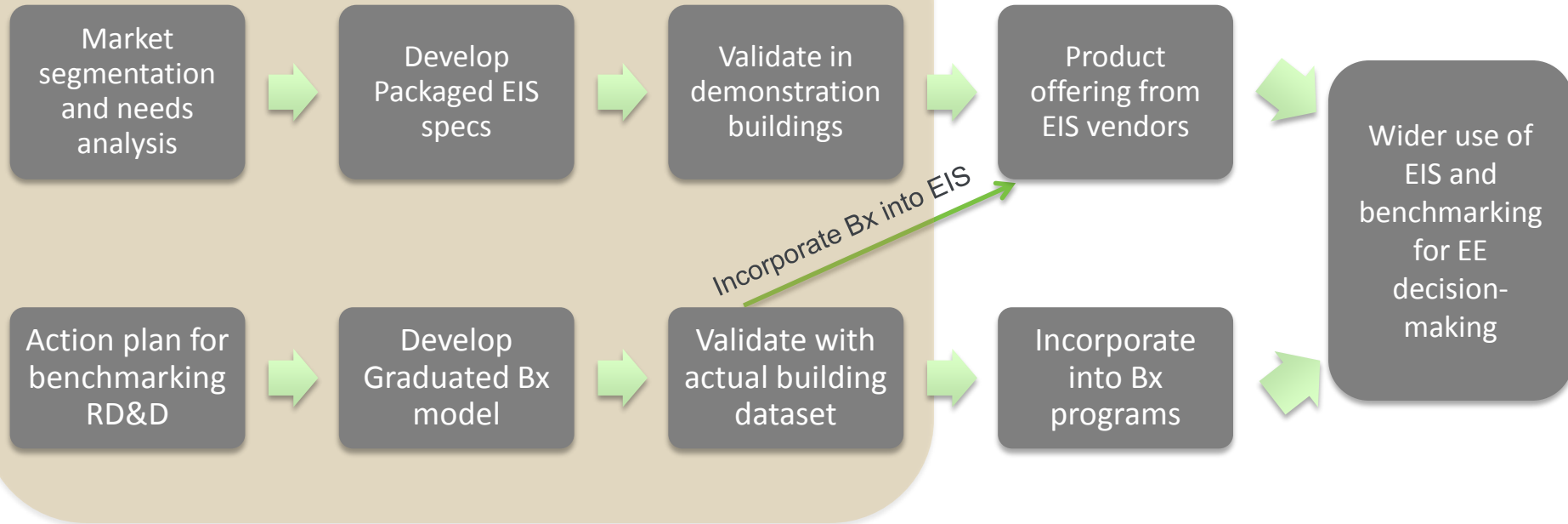
Approach: Overall Approach & Impact Model

Projected energy savings:

~68 TBtu/year (U.S.)

~7 TBtu/year (India)

CBERD project scope



EIS activities align to BTO's Commercial Integration Program's objective for "Building operators, managers, operators and investors to understand value and manage building energy performance."

Benchmarking activities align to BTO's Commercial Integration Program objective of building energy data transparency

Approach: Key Issues and Distinctive Characteristics

EIS

Key issues:

- How to engineer packages that accommodate heterogeneity across buildings.
- Engineering for simplicity – how to minimize expertise and time needed for installation and use of EIS packages.

Distinctive characteristics:

- “Commoditizing” EIS – not just features, but also ease of installation and use. Field tested.
- Eases sales cycle for vendors for new markets that previously were hard to access or had difficult sales cycle.

Benchmarking

Key issues:

- Identifying variables for each tier considering statistical significance and ease of data collection
- Modeling approach – independent models for each tier vs. Constrained regression vs. other
 - Univariate - Bivariate –Multivariate analysis
 - Graduated benchmarking model: Test and validate

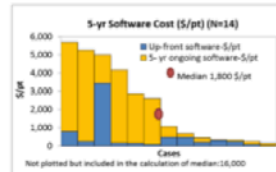
Distinctive characteristics:

- Uncertainty information for benchmark scores.
- Rigor tailored to programmatic needs.
 - e.g. Screening vs. incentive programs

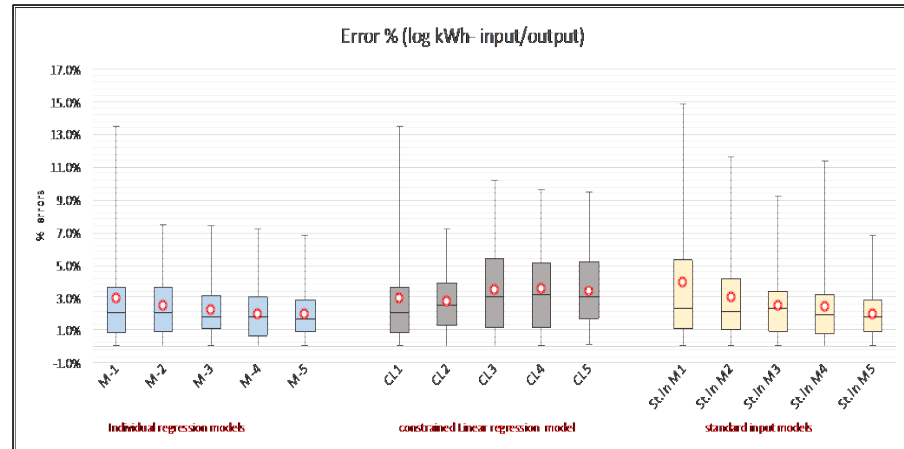
1. **Technical requirements** for a system that is packaged and standardized, with optimum, integrated components

2. **Cost Reduction** through analysis of hard, and soft transaction costs, and offer strategies for reduction of process times and delivery of EIS

3. **Efficacy** by offering guidance for simple in-house data-driven actionability for relevant stakeholders through tailored dashboards, targeted actions and alerts



Wide cost range for a custom EIS solution
Hardware + software= \$5K-\$20K+ per year



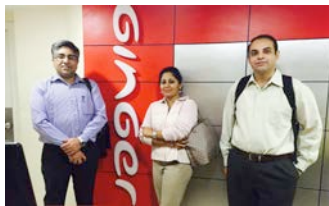
Progress and Accomplishments: Recent

EIS

- Office, Hospital, Hotels EIS-in-a-box technical requirements, demo installation, data analysis
- Transaction cost framework and analysis
- Dissemination and Outreach:
 - Website, blogs
 - Conferences: ACEEE Intelligent Efficiency, ACREX, SXSW Eco
 - Facilities networks: Center for Health Design

Benchmarking

- Specification of Commercial Building Benchmarking Database for India
 - Based on DOE Building Performance Database.
 - Data needed for various types of commercial building benchmarking analyses.
 - Database design, including Application Programming Interface (API) functions, data privacy considerations
 - Data input processes and data cleansing.
 - Software development, maintenance considerations



Ginger Hotel (Tata group)



Fern Hotel Ahmedabad



Akanksha Hospital Anand



Krishna Hospital, Anand



L&T Knowledge City, Vadodara



Schneider Offices, Gurgaon



Schneider Offices, Bangalore

Progress and Accomplishments:

Technical requirements for 2 tiers of EIS-in-a-box for 3 market segments

EIS Tier 1 (Entry) Package- Healthcare Facilities

WB
Grid electricity

WB:
Gas/Fuel oil
(U.S.)

Monitored loads

- Whole building
- 2-3 sub-meters for recommended end-uses/ spatial areas

WB
Diesel Generator
(India)

WB:
Steam

Sub-meter 1
Chiller Plant

Sub-meter 2
Heating
Boiler/ Furnace

Sub-meter 3
e.g. Ventilation
Fan energy

Input: Interval data from Building Systems

Gateway

Analysis

1. Simple tracking of energy use
2. Load profiling and peak loads analysis
3. Benchmarking (Longitudinal)
4. Cost tracking

Visualization

1. Standardized reports
2. Time series- line charts, bars, load profiles
3. Fuel/ cost pie charts

Notification

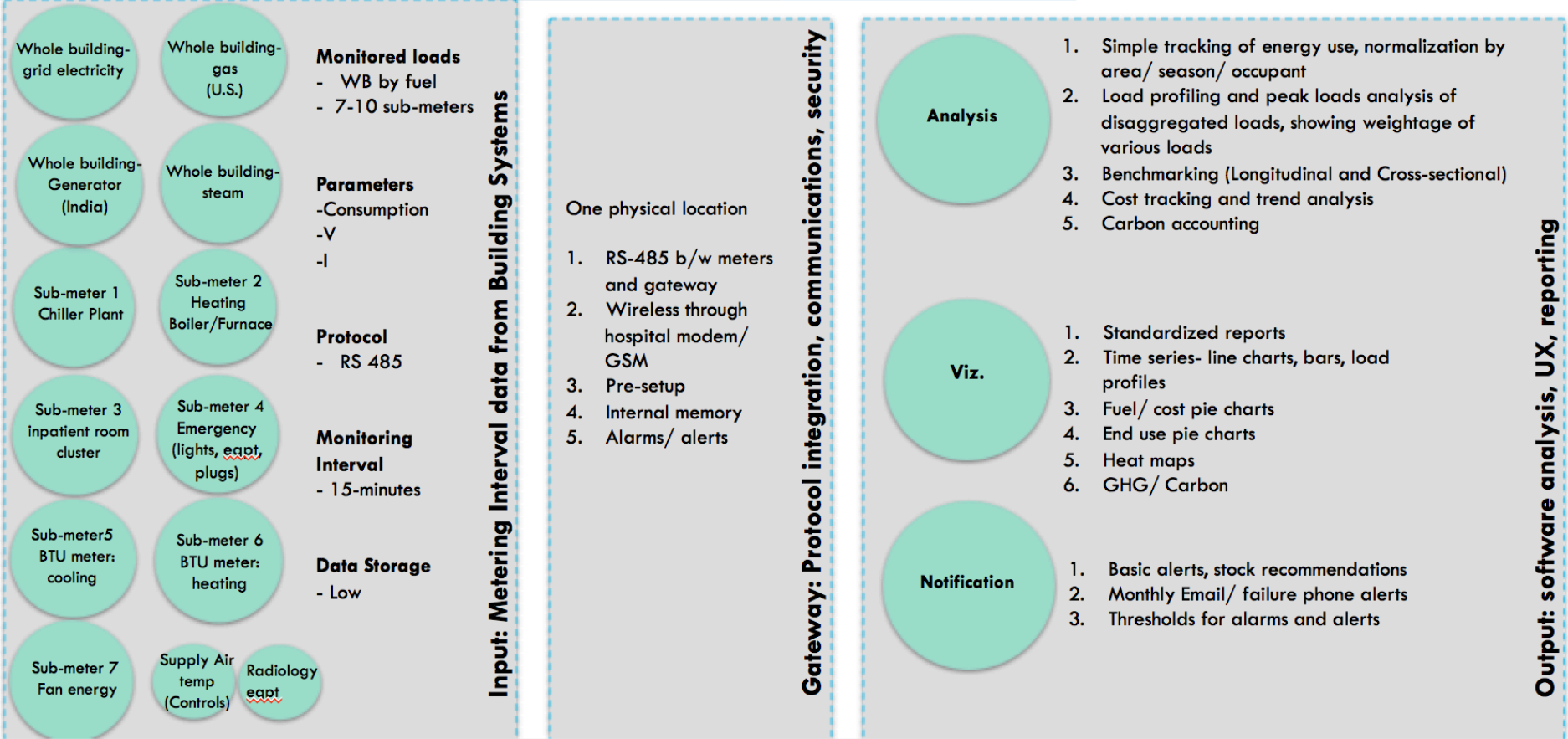
1. Basic alerts, stock recommendations
2. Monthly Email/critical failure phone alerts

Output: Analysis software, UX, reporting

Progress and Accomplishments:

Technical requirements for 2 tiers of EIS-in-a-box for 3 market segments

EIS Tier 2 (Advanced) Package- Healthcare Facilities

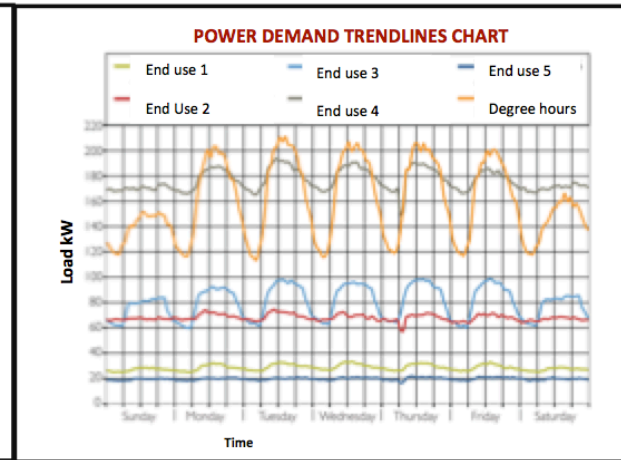
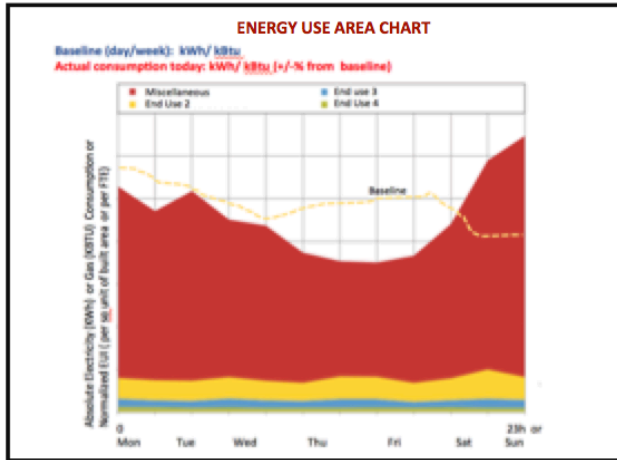


Progress and Accomplishments: EIS-in-a-box solution

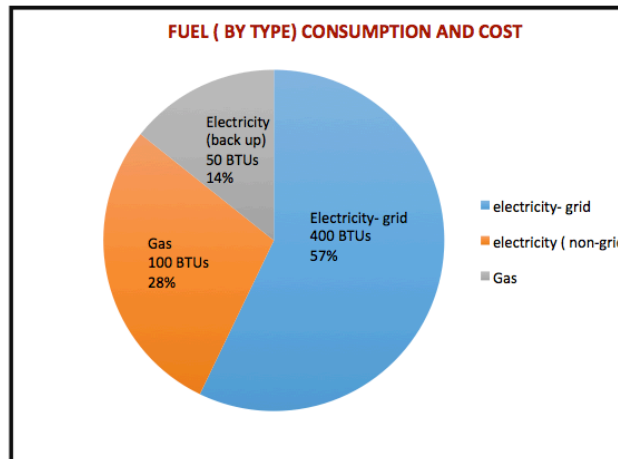
Facility Daily* Dashboard: Building Pulse at a glance

How much energy (by fuel) and cost is my building consuming, where and when?

- 1. Energy Use Area chart**
 (2 versions, for tier 1 and 2)
 Energy Consumption
- Electricity (kWh or kBtu)
 - Gas (therms or kBtu)



- 2. Power Demand Trendlines chart**
 (2 versions, for tier 1 and 2)
- Electrical Loads (kW)
 - Gas Load (kBtu/hour)

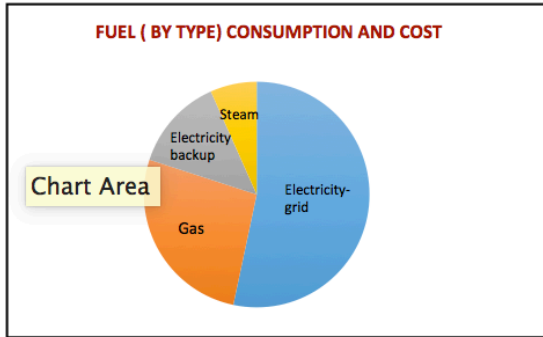


- 3. Fuel Cost, Consumption chart**
 (similar for tier 1 and 2)
- Consumption (kBtu):
 Electricity (grid, off-grid),
 Natural Gas
 - Cost (INR/\$)

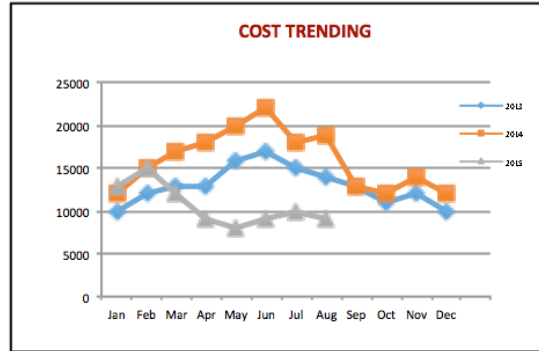
*Can be used by the facility staff on a daily or weekly basis

Progress and Accomplishments: EIS-in-a-box solution

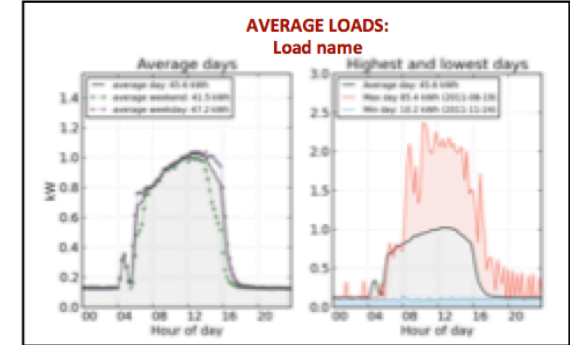
Monthly/ Annual Dashboard



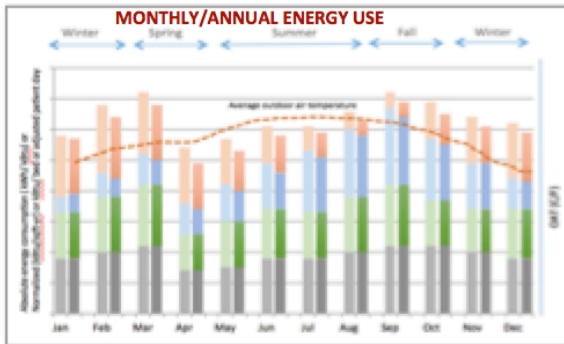
1. Consumption and cost per fuel type
(Similar for Tier 1 and 2)
\$ or kBtu/ time period



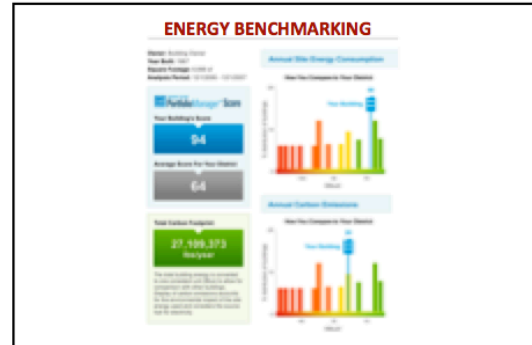
2. Cost trending
(Similar for Tier 1 and 2)
\$ or INR/ time period



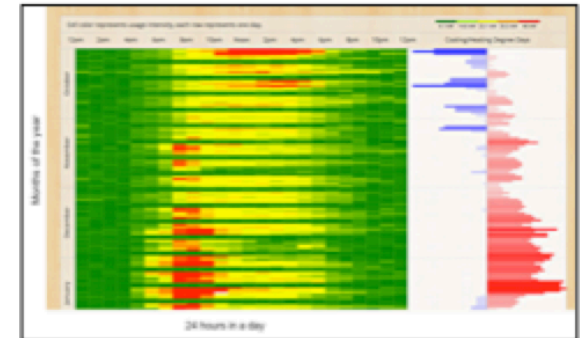
5. Average Loads line chart
(Similar for Tier 1 and 2)
- Electrical Loads (kW)
- Gas Load (kBtu)



3. Monthly/ Annual energy use and longitudinal benchmarking
(Similar for Tier 1 and 2)
Electricity (kWh), Gas (kBtu)



4. Cross-sectional Benchmarking (Tier 2 only)
- Portfolio Manager score
- Carbon footprint
- Comparisons with peer buildings in the district or nation



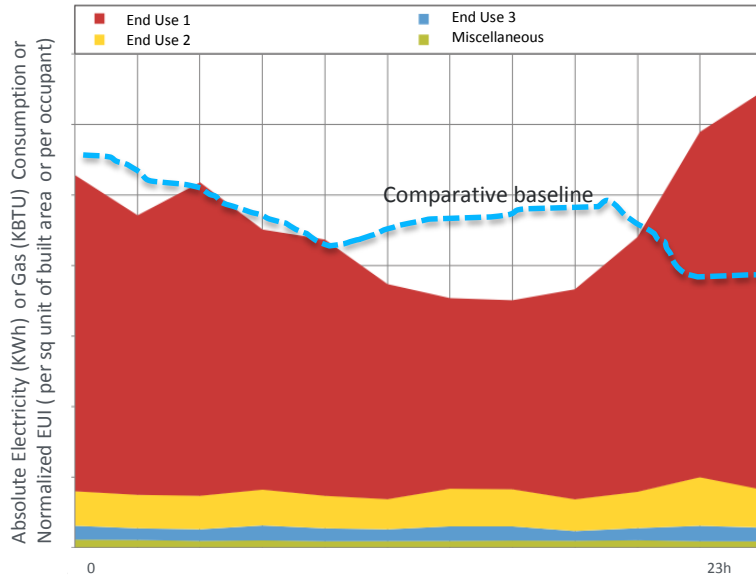
5. Whole Building Heat Map: (Tier 2 only)
- Electrical Loads (kW)

Executive level charts

Facility manager charts

Progress and Accomplishments: EIS-in-a-box solution

Facility Dashboard Chart #1: Energy Use Area chart



Toggle: Today/ Week/ Month/Year

Toggle: Absolute and normalized energy use

Overlay configurable whole building energy consumption baseline e.g. from previous day, or previous week, or long term average day in the year or average week in a year; based on facility manager heuristics

Qualitative insights:

- Shape: Expected use of building based on occupancy, schedule
- Diagnostics: Missing data, measurement fault, broken controls or equipment
- Disaggregation: Relative contribution of end uses

Quantitative information:

- Target consumption today
- Comparative Baseline (a previous day/week)
- Actual consumption today

Quantitative rule-based alerts, for e.g.:

- Variance +/-% from target: Screen alerts
- Variance : +/-% from baseline: Email/text alerts
- Variance beyond x%: Alarm

Enhanced usability with recommended pre-configured dashboards, and user training

Schedule

Control

Repair

Audit

Upgrade

In-house

Vendor-provided

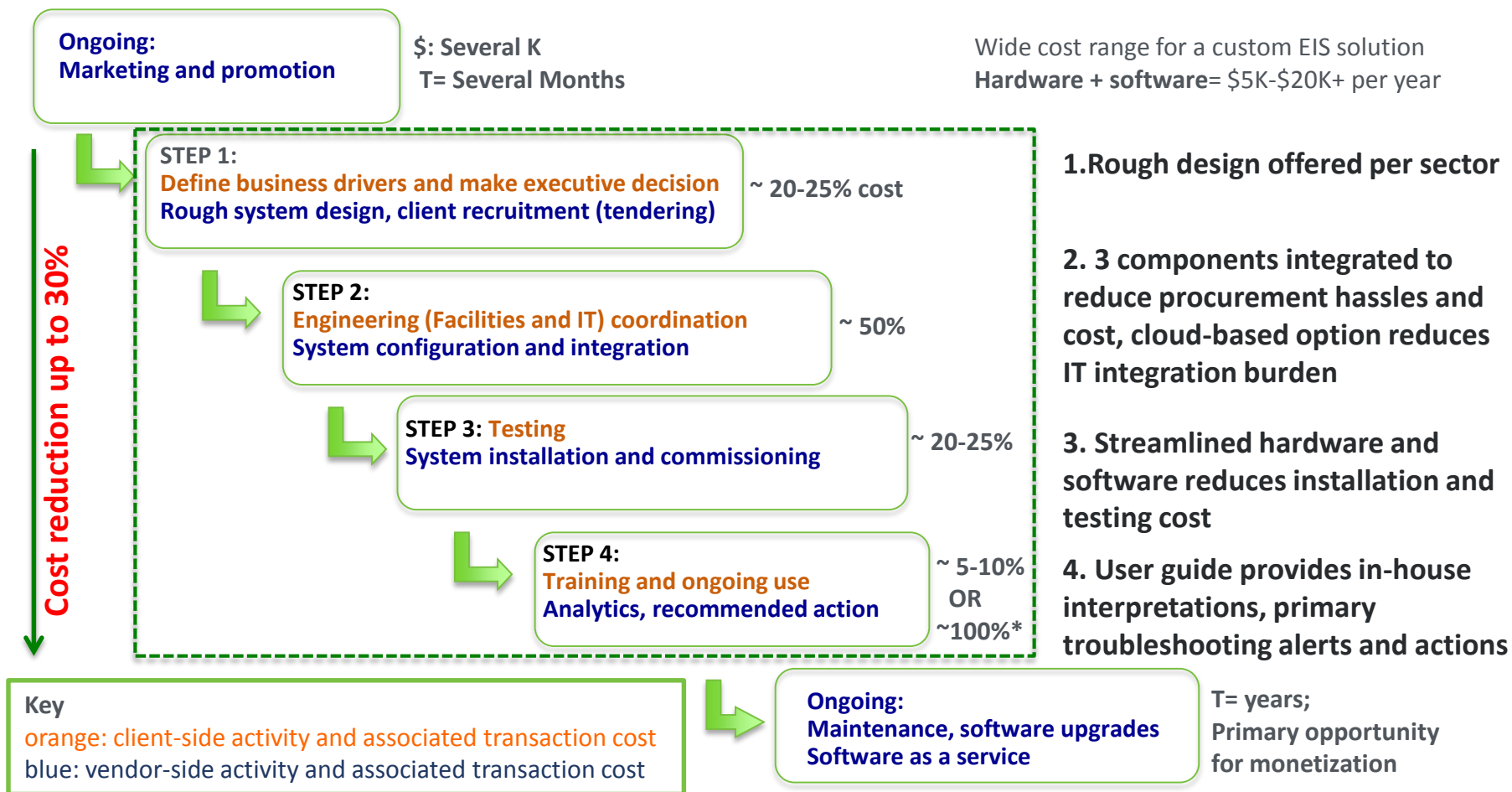
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Renewable Energy

Progress and Accomplishments: Market Impact

Potential reduction in EIS Transactional cost

Interviews conducted with industry partners and collaborators:
Schneider, Wipro/UT, Lucid, Solvista, Cascade, Gridium



Progress and Accomplishments: Market Impact: EIS-in-a-box solution

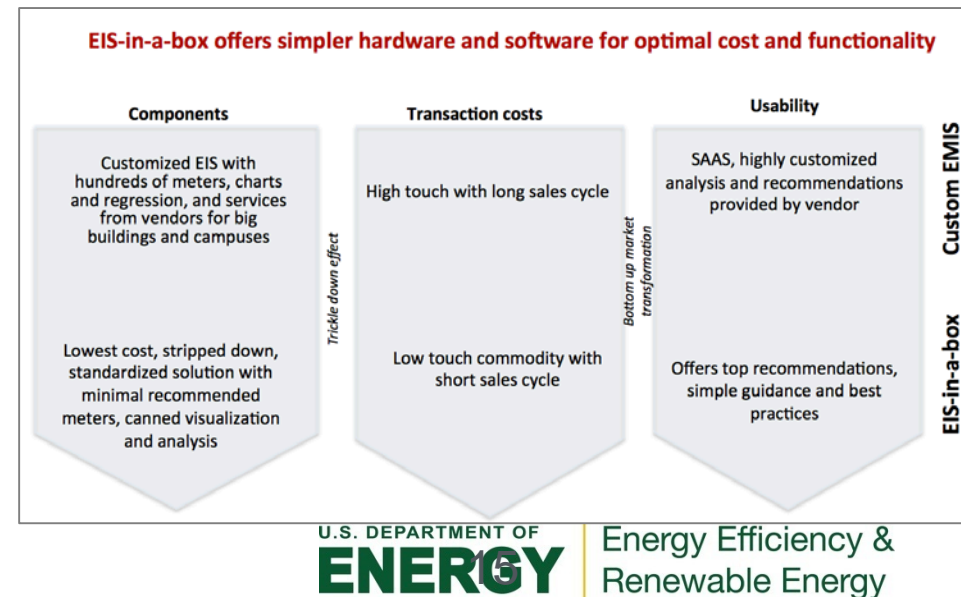
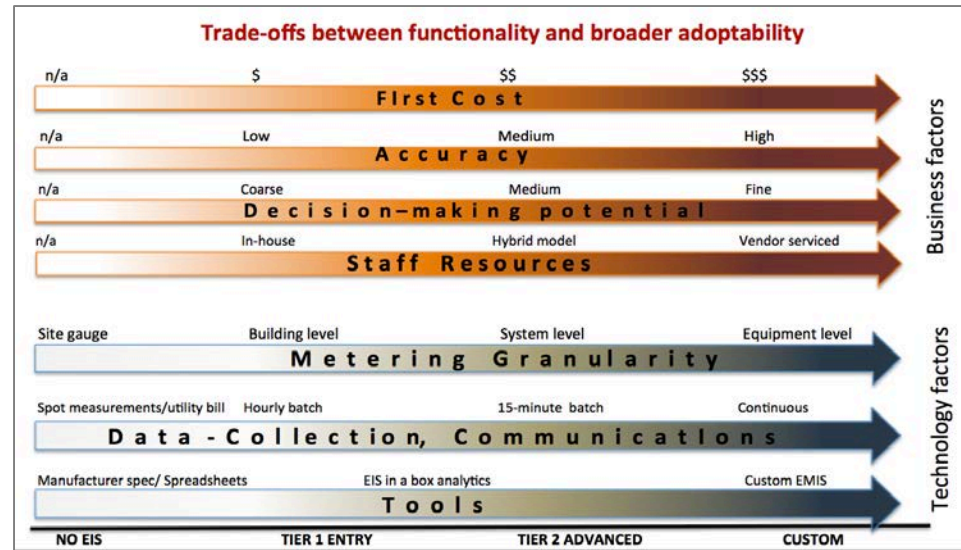
Making building energy information simple, scalable, and actionable

Lessons Learned

- Don't complicate data or develop sophisticated algorithms
- Use the 80-20 principle

Efforts to scale impact

- Offers **streamlined data architecture with right volume, variety and velocity of data**
- Available at a lower cost, with integrated hardware, software, and user interface
- Provides deepened intelligence for actionable insights; dashboards targeted to cut across organizational siloes
- Increases the ability for even stock, “non-heroic” buildings to be energy efficient and self-sufficient
- Enhances adoption of energy measurement and management accross the buildings sector



Global benefits



1. Project leverages bilateral research and development (R&D) strengths

- Benchmarking R&D assistance to Indian partner, as capacity building: <10% \$ spend
- Emphasis on creation of EIS in a box: builds on U.S. partner strength, demo in Indian buildings, to be applied back to U.S. buildings

2. Bidirectional relevance of outcomes

- Production efficiency: Joint SOW and deliverables
- Project cost-effectiveness. \$ goes ~10X further for Indian R&D time
- Energy reductions: highly relevant to both countries

3. Demonstrated value to US industry: access to markets, use of CBERD imprimatur

- U.S. industry partner Mazzetti opened new office in Bangalore, India; promoted CBERD through blog and industry's ACREX conference in India
- Wipro Eco-energy (acquired by United Technologies USA) developing CBERD imprimatur
- Schneider Electric developed and demonstrated CBERD imprimatur
- Vendors interviewed in U.S showed enthusiasm for such a EIS-in-a-box solution
- Executive level Facility VPs from U.S. facilities interested in potential pilots

Project Integration and Collaboration

Integration with DOE BTO Objectives

- The Better Buildings Alliance (BBA) could serve as a key audience for the work, and future deployment channel for the EIS results.
- Leverage CBERD deliverables (videos, specification, recommended dashboards) for DOE's M&V activities and Smart Energy Analytics campaign

Collaboration and Communications

- 3 US Project R&D Staff (LBNL)
 - focus is on EIS work
- 3 Indian R&D Project Staff (CEPT University, India)
 - focus is on Bx work (with LBNL input)
- Mazzetti, Schneider Electric India and Wipro Eco-Energy are very actively engaged on EIS.
 - Provide ongoing input/feedback on tech design.
 - Engaged in upcoming pilot demonstrations.
- Inputs from U.S. industry collaborators and practitioners
 - Transactional cost surveys
 - Outreach events: BBA webinars, ACEEE Intelligent Economy, SXSW Eco, Built Environment Network, ACREX conferences
- Technical reports available from cberd.org website



CBERD Staff presenting to facility executives of the Built Environment Network at Center for Health Design

Next Steps and Future Plans

Next steps for FY 17

- Testing and iterating tech specs for three sectors based on results from the demonstration sites
- Analysis of “Value of Information” of packaged EIS vs. custom EIS



New activities for expansion of current work, in a CBERD 2.0

- **Commercialization of energy information systems (EIS) for underserved building sectors.** Entails hand-off to vendors , pilots in U.S. buildings (Facilities executives are showing interest)
- **Integrating** tech requirements, dashboards and training videos with with BBA, EIS M&V and Smart Energy Analytics campaigns
- **Expanding to segments** such as retail, education
- **Integration of building energy benchmarking with EIS** through development of metrics and performance targets for design, commissioning and operations.
- **Integrate energy information and benchmarking with urban** infrastructure programs in the U.S. and smart city initiatives in India
- **Analysis and interpretation of decision making processes** across the energy investment lifecycle



Project Budget

Project Budget: \$150K per year for five years, total \$750 K

Variances: None

Cost to Date: ~\$600 K (until end-Jan 2017)

Additional Funding: Cost share of \$500K from industry partners. Average of \$100K/year

Budget History

FY 2013– FY 2016 (past)		FY 2017 (current)		FY 2018 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
\$450K	\$400K	\$150K (expected)	\$50K	-	-

Milestone Status

Project Schedule									
Project Start: 10/1/12		Completed Work							
Projected End: 9/30/17		Active Task (in progress work)							
		Milestone/Deliverable (Originally Planned)							
		Milestone/Deliverable (Actual)							
	FY2013	FY2016				FY2017			
Task 2: Monitoring and Benchmarking	Q1 (Oct-Dec)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)
FY16Q2 Milestone (EIS) Identification of Sites and Installation of Hospitals EIS package in 2 buildings;									
FY16Q2 Milestone (EIS) Technical requirements for packaged EIS for Offices;									
FY16Q2 Milestone (Bx) Specification for national benchmarking database for India, including data needs and fields; data definitions									
FY16Q4 Milestone (EIS) Identification of Sites and Installation of Offices EIS package in 2 buildings									
FY17Q2 Milestone (EIS) Analysis of data from EIS demonstration buildings									
FY17Q4 Milestone (EIS) Updated EIS package specifications based on demonstration buildings									